Space Weather Technical Forecast

Issued on Sunday, 10 July 2022 at 01:11 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of further M-class flares and R1/R2 Radio Blackouts. One CME pending analysis.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has reverted to Low in the past 24 hours, with isolated C-class flares recorded at GOES16, peaking with a C8.5 at 09/1348UTC. This emanated from a plage region on the southwestern limb, most likely that containing the remnant of AR3047, which presented as a Zurich Bxi at peak some days ago as it crossed the facing side. This was associated with a large non-Earth directed Coronal Mass Ejection (CME). Also of note was an impulsive C5.1 at 09/2103UTC, with this emanating from the trailing portion of previously quiet sunspot group AR3051 in the northwestern quadrant. Finally, a third event in the form of a long-period C4.6 was observed at 09/2245UTC from immediately east of AR3052. There is some evidence of a dimming in AIA 211 related to this event, which may mean a CME was generated. There is not yet any imagery to corroborate this, however being near the solar meridian, an Earth-directed component is very possible should a CME have been produced - this is an active area of monitoring.

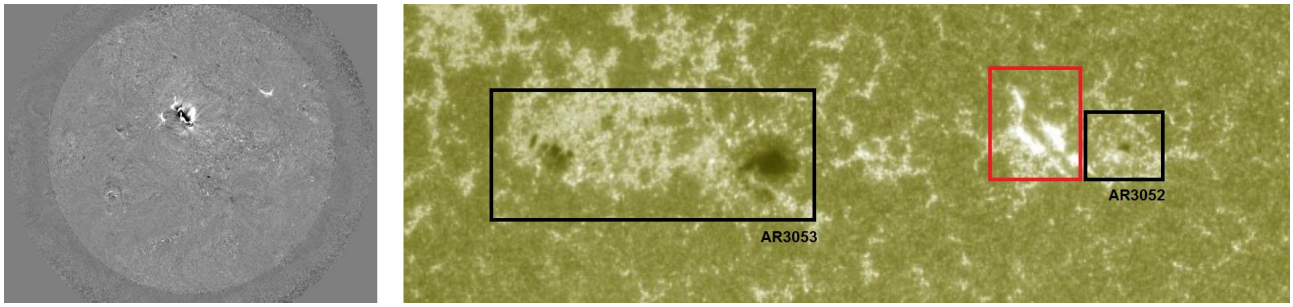

Figure 0: Time-integrated AIA211 image of dimming from the 09/2245UTC C4.6 flare, probably a signature of a CME being generated (processing courtesy of SIDC ROB). Also shown is AIA 1600 for the time of the flare, with the flare's location immediately abutting AR3052 shown boxed in red.

There were five numbered sunspot regions on the disc in total, with the two largest and most complex both occupying the eastern solar hemisphere. The larger and historically more active of the two was AR3053, which showed proliferation in its intermediate spots and some spreading to finish the UTC day of Saturday 09 July as an Eki/Beta, having produced an M2.5 flare and non-Earth-directed CME prior to this reporting period at 08/2048UTC. To its southeast, AR3055, while smaller, showed more change overall, with central spot development, areal growth and spreading all contributing to an eventual class of Esi/Beta, although no significant flare activity was recorded. Rounding out the front-side population of sunspot groups, AR3046 and AR3052 were both unremarkable and stable Hrx/Alpha groups.

There are currently numerous large filaments on the Sun, with the southeast quadrant in particular harbouring two large features that each span roughly 20 degrees on the solar disc. There were no

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signs on instability in these in the reporting period, however they will become increasingly relevant should they lift off in the coming few days, and will be monitored.

No Earth-directed CMEs have been observed in available imagery over the past 24 hours. The C8.5 flare CME was modelled and determined to carry no Earth-directed component. A second CME from the western solar hemisphere was determined to be far-sided from an unknown source near 120W, again with no Earth effects anticipated.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by DSCOVR at L1, generally followed a slow regime, with minor SSBCs observed, with the phi angle most often orientated in a weakly positive direction (away from the sun).

The solar wind speed showed a slight decline within background levels, falling from 375 to 325km/s within the first three hours of the time window, before a gradual recovery to regain this lost ground over the rest of the period. The solar wind density was mainly within usual background levels, peaking near double figures ppcc in the middle of the UTC day. The IMF showed an early peak at 7nT, with the north-south component ranging between +7 and -5nT, spending much of the first half of the day co-aligned with Earth's field, before a more erratic character took over later in the afternoon and evening.

The net result of the above solar wind measures was nevertheless almost entirely Quiet over the 24 hours, peaking at a provisional Kp of 3- in the 12-15UTC window.

Energetic Particles / Solar Radiation: The high energy proton flux (10 MeV), as measured by GOES16, showed a response in the lower end of the spectrum in the wake of the C8.5 flare from the limb, with greater than 10MeV rising to a peak of around 4pfu in the following hours, maintaining this level into the UTC evening. The harder end of the spectrum was relatively unresponsive to the same stimulus.

The high energy electron flux (greater than 2MeV) remained at Normal Background levels. The corresponding 24-hour integrated electron fluence remained well below the Active (1e8 integrated pfu) threshold on a roughly level trend. Observed fluence was 1.62e6 integrated pfu at 10/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is Likely to remain Low, but with a daily Chance of M-class flares. A progressive slight increase is possible in the four days, with the sunspots that present the greatest risk of flares still in the eastern solar hemisphere, possibly bolstered by further arrivals over the northeastern limb into the new working week UTC.

Solar Wind / Geomagnetic Activity: No CMEs feature in this forecast.

Solar winds are expected to follow a slow regime initially. Recent STEREO A measurements suggest effects from CH99/+ may present at Earth from Monday 11 July, albeit with low confidence for bearing little resemblance to last rotation and possessing a very fragmented leading edge. All considered, there is a Slight Chance of a G1/Minor Storm at this time, reducing to more reliably Quiet levels once again towards midweek.

Energetic Particles / Solar Radiation: In the absence of any significant sunspot development, the high energy proton flux (greater than 10 MeV) is likely to remain at Background levels. There is a daily Slight Chance of S1 or greater, with risks from the southwest limb feature bolstered by the westward progression of the front-sided large sunspot groups.

The high energy electron flux (greater than 2MeV) may increase at the end of this period, but the

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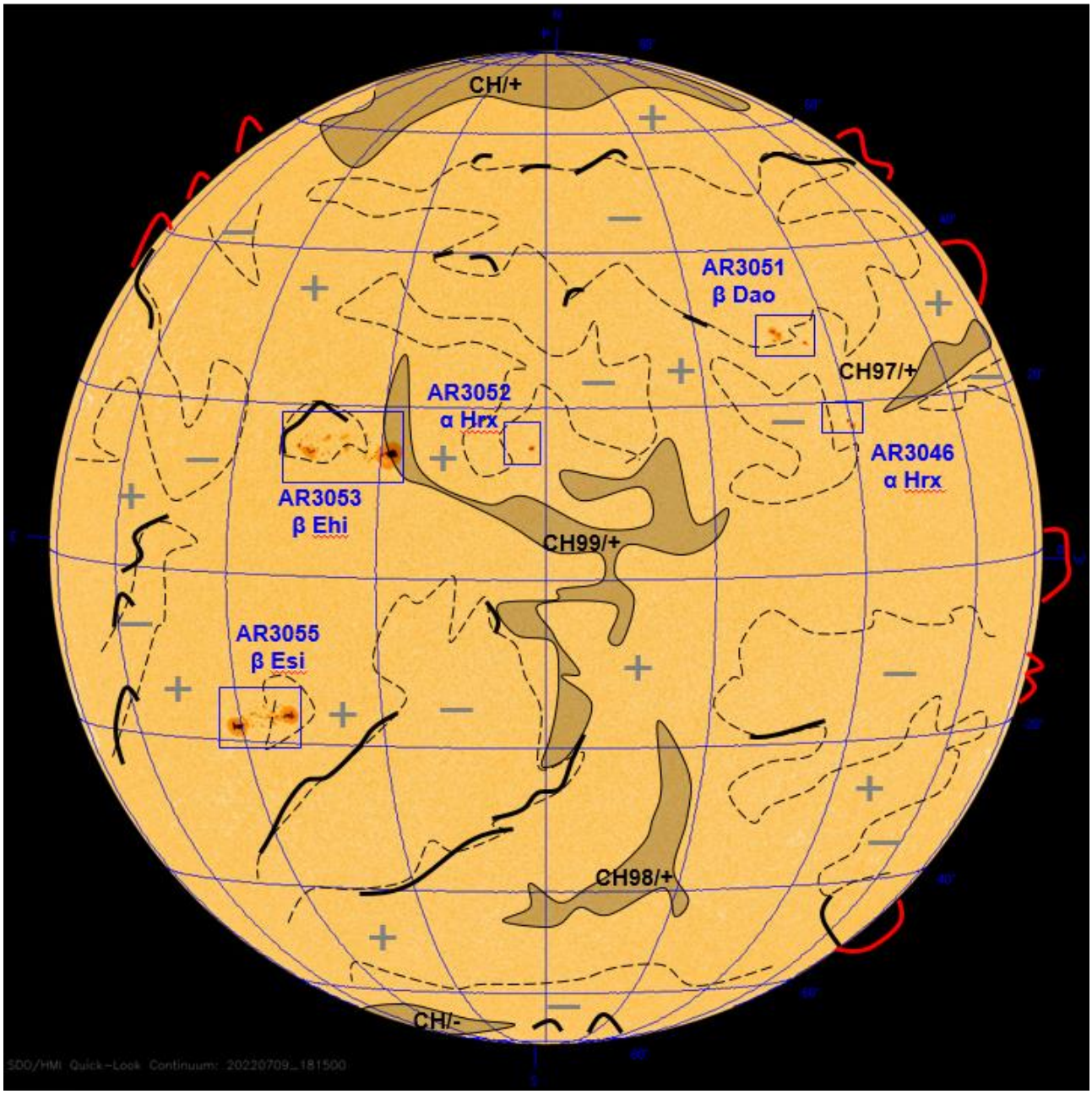
corresponding fluence is Likely to remain well below the Active threshold (1e8 integrated pfu).

Figure 1. Solar Analysis Valid 09/1815UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

No CMEs feature in this forecast, however there is one unassessed candidate at the time of writing discussed in the Solar Activity section.

The solar wind parameters are now exhibiting a slow regime, and the next coronal hole worth of note is the very fragmented CH99/+. This is a recurring feature that generated speeds of 600km/s on the previous rotation, however, due to its smaller size and fragmentation in the intervening month, it is hard to envisage similar will be achieved this time around.

STEREO A does show an analogous enhancement in recent hours associated with a positive phi angle, which would correlate to an arrival at Earth on Monday 11 July which would be 24 hours earlier than expected versus SWPM. Some additional influence is possible from CH98/+ by midweek, although any distinction is not likely to be possible given the identical phi angle.

Geomagnetic activity should therefore start largely Quiet with the odd Unsettled interval, rising to a peak Slight Chance of a G1/Minor Storm on Monday 11 July before becoming more reliably Quiet once again by midweek UTC.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	20	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil, but note unassessed candidate discussed in solar activity section.

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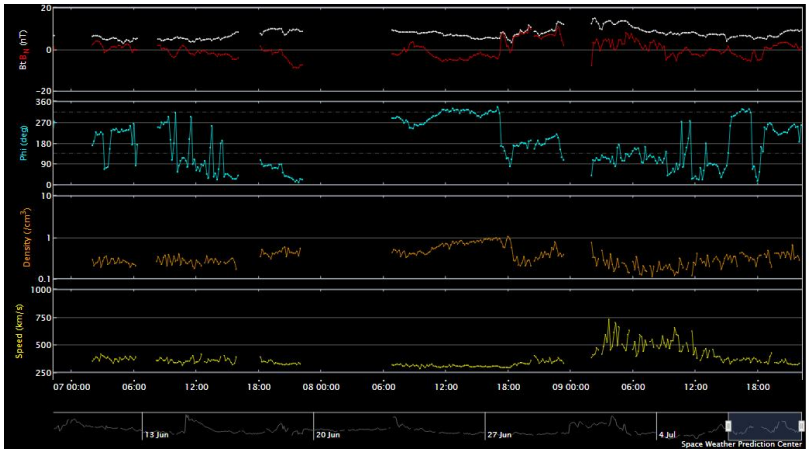
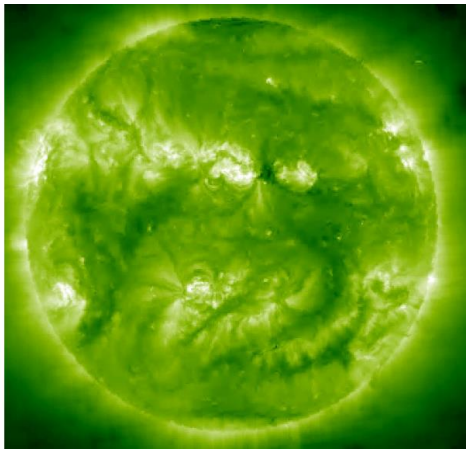
Figure 2: STEREO A MAG and PLASTIC measurements from the past three days, showing a solar wind enhancement probably corresponding to CH99/+ due at Earth inside two days' time. The disc as seen from STEREO A is also shown in the form of EUVI 195, right, with CH99/+ the dark feature narrowly in the western solar hemisphere.





Radio Blackouts - X-Ray Flares:

There are currently five sunspot regions on the visible disc, with the risks of significant flares dominated by a pair of Zurich E-groups in the eastern solar hemisphere. Both of these have shown a growing tendency in recent hours, although are perhaps slightly under-active for their class on paper. Despite this, there is felt to be a daily Chance of M-class flares, with risks maintained near the raw probabilities for the disc.

Regarding trends, neither of the two large sunspot regions depart the Earth-facing side in the four-day period, while there is some evidence of further arrivals over the eastern solar horizon. Bright flux regions are visible in EUVI195 in the northeast, with these likely to progressively cross onto the disc into the new working week UTC, although the degree to which these affect the flare forecast remains to be seen.

X Ray Flares / **Probability**	**Level**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)** / **(%)**	**Day 2 (00-24 UTC)** / **(%)**	**Day 3 (00-24 UTC)** / **(%)**	**Day 4 (00-24 UTC)** / **(%)**
Active	**R1-R2 M Class**	No	40	40	40	40
Very Active	**R3 to R5 X Class**	No	5	5	5	5

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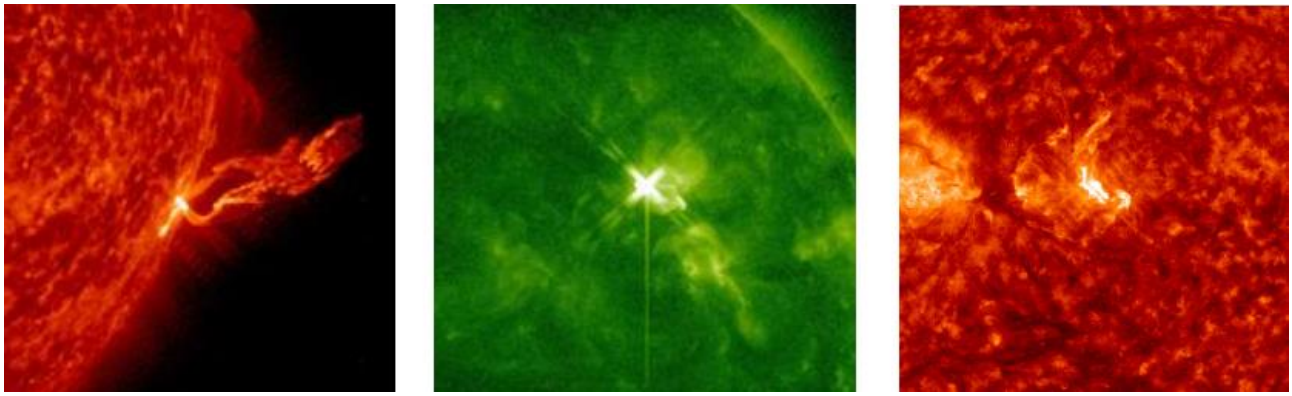
Figure 3: AIA 304, 94 and 304 imagery of the three most significant X-ray flares in the period, respectively from Ex-3047; AR3051 and near AR3052.



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) is currently slightly elevated at the low energy end of the spectrum in response to the C8.5 flare from Ex-3047. Flux levels are therefore starting from a slightly higher baseline should any further events occur from the limb or one of the large front-sided sunspot groups - most of the latter being in the eastern solar hemisphere at present.

All considered, there is a slightly greater risk of S1 in the four days relative to previous guidance, with the upward tendency in risk perhaps approaching 10% towards midweek.

Radiation Storms Probability (Exceedance)	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC) (%)**	**Day 2 (00-24 UTC) (%)**	**Day 3 (00-24 UTC) (%)**	**Day 4 (00-24 UTC) (%)**
Active	**≥ S1**	No	5	5	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES16 high energy protons and driving GOES16 X-ray flux. Note the response in 10MeV protons to 4pfu in the wake of the C8.5 flare.

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High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) is currently at Normal Background levels, and the diurnal pattern in response to CH97/+ now ought to be apparent, i.e. current flux levels are probably already the peak for this feature.

While CH99/+ is a persistent feature, it is much-changed in comparison with the previous rotation, and as such confidence is relatively low. 600km/s fast winds and a Slight Chance of G1 ought to make an impression in flux levels, with these rising to a new equilibrium before midweek UTC, albeit most likely comfortably short of 24-hour integrated Active fluence levels.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	20	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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